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FLATHEAD LAKE BACTERIOLOGICAL STUDY

Ralph R. Bauer

Pacific Northwest Water Laboratory
Corvallis, Oregon

April 1969

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Flathead Lake Bacteriological Survey

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CLEAN WATER

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FLATHEAD LAKE BACTERIOLOGICAL STUDY

Prepared by

Ralph R. Bauer
Technical Assistance
and Investigations

U. S. Department of the Interior
Federal Water Pollution Control Administration
Northwest Region
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April 1969

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INTRODUCTION

Problem

On June 5, 1967, the State of Montana adopted the following coliform standard for Flathead Lake:

> "Organisms of the coliform group by the most probable number (MPN) or equivalent membrane filter (MF) methods, during any consecutive 30-day period and using a representative number of samples, shall: average less than 50/100 milliliters (ml) when demonstrated by sanitary survey to be a result of domestic sewage[1/]."

Past coliform data have been reported which indicated that coliform concentrations exceeded the state standard in certain portions of the lake. State officials were concerned with these reports primarily because many lakeside residents use untreated lake water for a domestic water supply. The paucity of data, however, left some doubt as to whether the reported coliform levels were truly representative of the existing water quality, and if so, to what extent the area was affected. The Montana State Department of Health, Division of Environmental Sanitation, requested assistance from the Federal Water Pollution Control Administration to resolve this question.

Purpose

The purpose of this survey was to determine the concentration and distribution of coliform bacteria present in Flathead Lake,

Montana, during a heavy use period as compared with the applicable state water quality standards. The term "coliform" means total coliform except when otherwise stated.

Scope

1. Location - This study was limited geographically to Flathead Lake, Montana, and the rivers and streams that enter the lake (see Figure 1).

2. The Study - The study was undertaken during the summer of 1968 and consisted chiefly of a sampling and analytical program designed to permit a bacteriological evaluation of Flathead Lake water quality during periods of peak water use.

Authority

The Federal Water Pollution Control Act, as amended, provides authority for this study.

Acknowledgments

The assistance and cooperation of the Montana State Department of Health, Division of Environmental Sanitation; University of Montana, Yellow Bay Biological Station; Lake County Health Department; and the U. S. Weather Bureau are gratefully acknowledged.

SUMMARY

The following are findings of this study which relate to the occurrence and distribution of coliform bacteria in Flathead Lake.

1. Total coliform standards were exceeded at 14 of 20 near shore stations during the July survey and 15 of 20 near shore stations during the August survey.

2. The occurrence of total coliform densities in excess of the state standard corresponds generally with areas where high levels of human and/or animal activity are found.

3. Total coliform counts at near shore stations varied markedly from day to day and from station to station.

4. Total and fecal coliform bacteria in near shore waters were found at all depths.

5. Wind driven waves caused lateral movement of the near shore water in the direction of wave motion, thus providing a vehicle for total and fecal coliform transport.

6. Total and fecal coliform densities decreased rapidly in water samples taken progressively farther from the shoreline.

7. All off shore stations demonstrated consistently low total coliform concentrations, most values being less than 2/100 ml.

8. No fecal coliforms were recovered from the established off shore stations.

9. Fecal coliforms were recovered from all near shore stations.

10. Runoff associated with heavy rainfall caused significant increases in near shore total and fecal coliform concentrations.

11. The drainage ditch in Polson, ~~locally referred to as the "government drain,~~" is grossly polluted and produces total coliform levels in excess of state standards where it empties into Flathead Lake.

12. Total and fecal coliform densities 100 yards downstream from the Big Fork sewage outfall and one-quarter mile downstream from the Kalispell Air Force Station sewage outfall were not significantly higher than the total and fecal coliform densities upstream from these outfalls.

13. Septic tank seepage into the lake was shown to be capable of producing total coliform densities greatly exceeding the state standard.

STUDY AREA DESCRIPTION

Geography

Flathead Lake is located approximately 15 miles southeast of Kalispell, Montana. The lake is 28 miles long and has a maximum width of 15 miles. One hundred eighty-five miles of shoreline enclose a water surface area of 188 square miles. The surface elevation of Flathead Lake is regulated by Kerr Dam on the Flathead River four miles downstream from the natural sill of the lake. The altitude of the lake surface lies between 2883 feet and 2893 feet during years of normal runoff. Flathead Lake is quite deep, many areas being over 200 feet in depth.

Geology

Flathead Lake was formed during the Ice Age when a glacier advanced from southern British Columbia through the Rocky Mountain Trench to the vicinity of Polson, Montana[2/]. A subsidiary lobe of the glacier extended up Big Arm to the vicinity of Elmo. This glacial action resulted in the deposition of terminal moraine at Polson and Elmo and a scouring of the valley walls in the Rocky Mountain Trench. The Polson terminal moraine formed a natural barrier to the Flathead River causing a lake to be formed in the glacially eroded valley.

The exposed bedrock of the valley walls was gradually covered with a thin layer of soil. This combination of a shallow soil

layer covering impermeable bedrock promotes ground water drainage into the lake. Land at the north end of the lake was gradually built up by the silting action of the Flathead River.

Climate

Data collected by the U. S. Weather Bureau at the Kalispell Airport are representative of climatic conditions at Flathead Lake. The mean average temperature at Kalispell is 43.9°F, the warmest temperatures generally occurring during July and August. Average temperatures for July and August are 68.7 and 66.4°F, respectively. It is significant that the warmest months are also the periods of maximum precipitation. The months of May through September commonly are the wettest, 1 to 3 inches being a representative monthly average for this period. Showers and thunderstorms furnish a significant portion of the warm season rainfall[3/].

Climatic conditions relate to coliform levels in Flathead Lake in the following ways: (1) land runoff due to rainfall is a source of coliforms, (2) warm weather promotes body contact water recreation, and (3) domestic consumption of water increases during warm weather.

A summary of past weather data, as well as the weather encountered during this study, is presented in Table 1, Appendix A.

Population

The permanent population of the communities surrounding Flathead Lake is estimated at 4,500. This figure increases to 15,000 if the city of Kalispell is included. Approximately 90 percent of the permanent population is served by some form of municipal sewage treatment (see Table 12, Appendix A).

The Flathead Lake area experiences a large increase in population during the summer months. The summertime population, although not well documented, has been estimated as being three times that of the permanent population. Seasonal residents are quartered primarily in vacation homes, state and privately owned campgrounds, motels and lodges. Most of these facilities use septic tank systems for sewage treatment.

Economy

Agriculture forms the economic base of the Flathead Lake area. Extensive cherry and apple orchards are found on the east side of Flathead Lake. The land north of the lake is cultivated to yield various grain crops. A thriving cattle industry also exists in this region, with cattle-grazing practiced along the southern and western sides of the lake. Lumbering and wood products production are also pursued extensively in the area around the lake.

Tourism is another major industry in this region. The lake is ringed with motels, campgrounds, lodges, etc., to accomodate the thousands who visit Flathead Lake and nearby Glacier National Park.

Water Use

The water quality standards for Flathead Lake are designed to protect the water for the following uses:

1. Public water supply
2. Fishing and recreation
3. Agriculture
4. Industrial water supply
5. Water power

Water supply is the most important protected water use in terms of the study. The stringent coliform standards for Flathead Lake are directed primarily at water supply protection.

SAMPLING AND ANALYTICAL PROGRAM

Survey Dates Selection

The choice of a sampling period was based upon the desirability of making bacteriological measurements during times of greatest expected bacterial loading and water use. Factors influencing bacterial loading include land runoff, population fluctuations, and body contact water recreation. All of these elements are most pronounced at Flathead Lake during the summer. Coincidentally, water usage is also greatest during this period.

Surveys were, therefore, scheduled and conducted on the following dates:

July 15-21, 1968

August 12-23, 1968

Sample Point Selection

For the purpose of this study, Flathead Lake was arbitrarily divided into two categories, near shore and off shore water. It was expected that the highest bacterial concentrations would be found near the shore because the majority of coliforms would enter the lake from the land. Further, the predominant water uses are associated with near shore water. For these reasons, emphasis was placed on near shore samples both in numbers of sample stations and frequency of sampling. Based upon the above

considerations, the following general sampling schedule was developed.

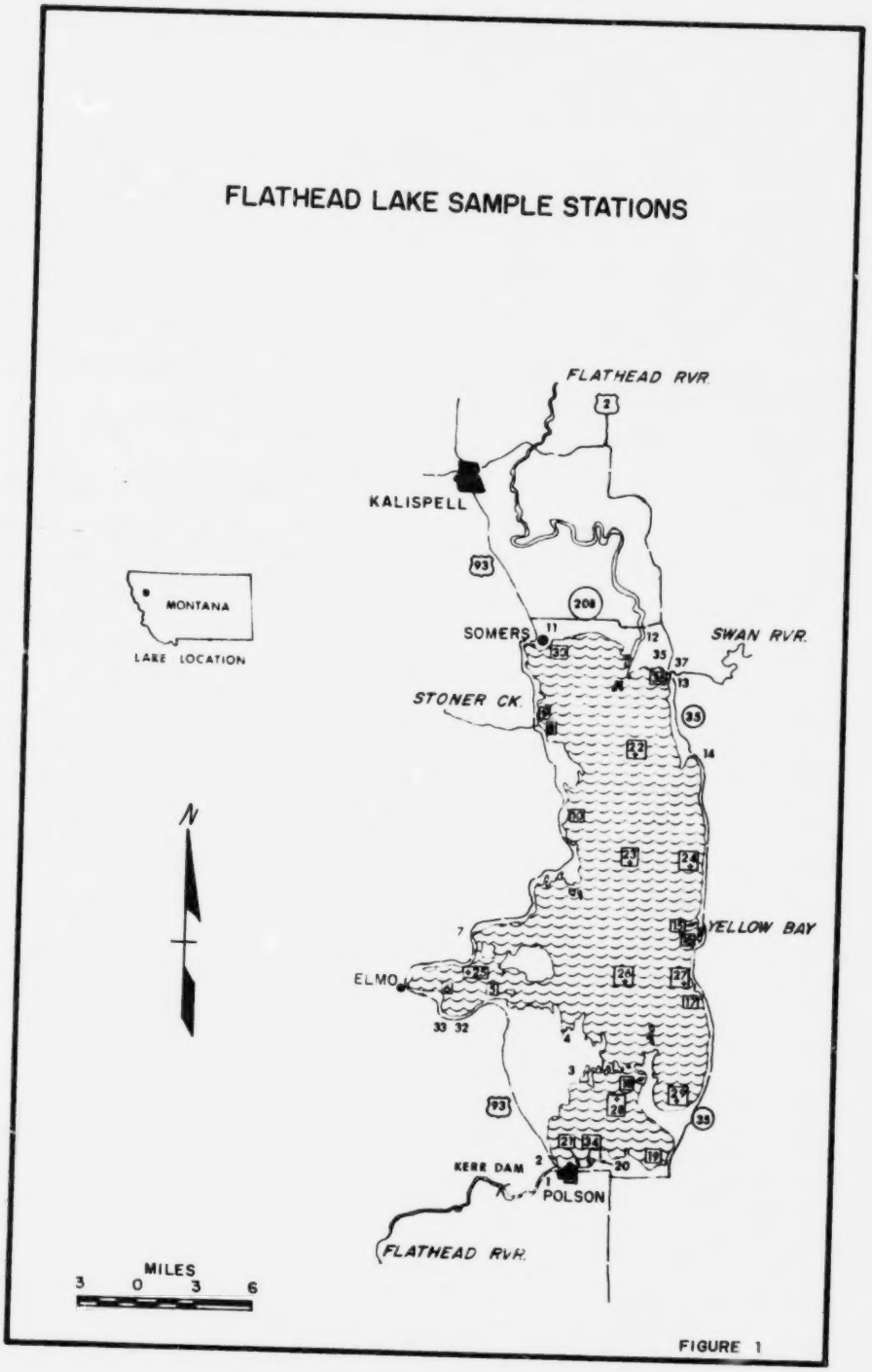
Near Shore

Near shore, for the purpose of this study, is defined as any water within 100 feet of the shoreline. Priority in sample point locations was given to areas where past data indicated coliform densities to be in excess of the state standard. Special consideration was also given to areas which receive a high level of recreational use and those areas bordered by a large number of lakeside homes.

Off Shore

Off shore water is herein defined as all that water which is more than 100 feet from the shoreline. Nine off shore sample sites were established using the intersects of a rectangular grid system based upon 5 minute increments of latitude and longitude. The coordinates of these intersects are listed in Table 1, Appendix B. One minute of latitude equals about 1.15 miles and one minute of longitude equals about 0.8 miles in this area (see Figure 1, Stations 22-29).

Figure 1 shows the locations of both near shore and off shore stations.


FLATHEAD LAKE SAMPLE STATIONS
FLATHEAD RVR.
KALISPELL
MONTANA
LAKE LOCATION
SOMERS
SWAN RVR.
STONER CK.
YELLOW BAY
ELMO
KERR DAM
POLSON
FLATHEAD RVR.
N
MILES
3 0 3 6
FIGURE 1

Sampling Procedure

Daily surface samples were taken by hand at each of the near shore stations using sterile 250 ml wide-mouth bottles. The following data were recorded with each sample: station number, temperature, time and remarks, e.g., approximate number of bathers, etc. Depth samples were taken on alternate days at those stations which were sampled by boat. The depth at which the samples were taken varied between 5 and 10 feet, depending upon the total depth of the lake at that location. Depth samples were initially taken with either a Kemmerer or a ZoBell JZ Sampler*. Although both methods were equalivent, the JZ Sampler was soon adopted for all routine work due to operator preference.

Surface samples were taken on alternate days at each off shore station. No depth samples were taken for these stations.

Sample collection was conducted from a boat or from the shore, whichever was more practical. The collecting sequence was reversed daily in order to alter the time of collection from day to day. Immediately after collection and labeling, all samples were iced for transport to a mobile laboratory located at Yellow Bay.

All major water courses entering the lake were sampled with the same frequency as the near shore stations.

*Use of product and company names is for identification only and does not constitute endorsement by the U. S. Department of the Interior or the Federal Water Pollution Control Administration.

ANALYTICAL METHODS

General

The coliform group of bacteria has been used for many years as an indicator of water pollution. Coliform bacteria are found in great numbers in the fecal excrement of all warm-blooded animals, including man; therefore, their presence in water is considered evidence of possible pathogenic contamination.

The group of organisms generally referred to as coliforms can more properly be called "total coliforms." Total coliform bacteria are also found in the soil and in association with many types of vegetation, thus leading to confusion as to their sanitary significance. In recent years, a more specific test has been developed which measures "fecal coliforms[4/]." Fecal coliforms can be simply defined as coliform bacteria of fecal origin. Both human and animal excrement contains "total" and "fecal coliforms." Fecal coliforms are not necessarily of human origin.

Quantitative procedures have been developed to enumerate the total and fecal coliform bacteria in a water sample. Two procedures are in general use, the most probable number (MPN) technique and the membrane filter (MF) technique. These procedures for measuring coliform concentrations are designed to indicate the degree to which water is contaminated with waste material from animal and/or human sources.

Analytical Procedures

Upon receipt at the laboratory, each sample was logged in and assigned a laboratory number. All samples were then analyzed for total and fecal coliforms by the membrane filter method. Total coliform determinations were conducted in accordance with the 12th Edition, Standard Methods for the Examination of Water and Wastewater[5/].

A membrane filter procedure for fecal coliforms is not yet included in Standard Methods; however, Geldreich et al.[6/] have described a fecal coliform medium for use with the membrane filter. Further studies by Geldreich[4/] have established the comparability of this procedure with the MPN fecal coliform test described in Standard Methods.

RESULTS AND DISCUSSION

Lake Sampling

Near Shore Stations

Over 500 water samples were collected from the established near shore stations during July and August 1968. Analysis of each sample for total and fecal coliforms yielded results as summarized in Tables 1 and 2. Both surface and depth samples are included in this data. Montana water quality standards for Flathead Lake require that coliform bacteria not exceed an average concentration of 50 coliforms/100 ml. In this study, average total coliform counts exceeded the state standard at 14 of 20 stations during the July survey and at 15 of 20 stations during the August survey.

Prominent in the (or these) near shore data is the wide range in the total coliform values (see Tables 2 and 3, Appendix A). To illustrate the nature of this variability, a frequency distribution plot was prepared for Station 20 (Figure 2). Frequency distribution plots of other near shore stations yielded similar patterns. The salient feature of this frequency distribution is the preponderance of low values accompanied by a few very high values.

Arithmetic averages calculated from skewed data, as found in Figure 2, can be misleading because extreme values markedly influence this statistic. For example, the arithmetic average of the data

TABLE 1

SUMMARY OF TOTAL COLIFORM COUNTS AT NEAR SHORE STATIONS

Station #	Location	July Survey				August Survey			
		# Samples	Total Coliforms/100 ml Maximum	Minimum	Average	# Samples	Total Coliforms/100 ml Maximum	Minimum	Average
1	Riverside Swimming Area	13	1,900	24	220	10	3,300	78	830
2	West End #93 Bridge, Polson	12	250	<2	47	10	62	4	27
3	Queen's Bay	16	120	<2	19	16	570	<2	88
4	Indian Bay	18	76	<2	11	17	240	<2	45
5	Walstead Memorial Park	12	150	4	59	10	3,200	22	680
6	Flathead Lake State Park	15	580	<2	130	10	4,900	32	600
7	Dayton Dock	13	320	10	97	10	600	4	140
9	Lakeside Public Beach	14	330	4	86	9	290	18	79
10	West Shore State Park	13	260	6	39	10	5,300	10	620
11	Bailey's Landing	12	290	<2	53	10	610	18	180

TABLE 1 (CONT.)

SUMMARY OF TOTAL COLIFORM COUNTS AT NEAR SHORE STATIONS

Station #	Location	July Survey # Samples	July Survey Total Coliforms/100 ml Maximum	July Survey Minimum	July Survey Average	August Survey # Samples	August Survey Total Coliforms/100 ml Maximum	August Survey Minimum	August Survey Average
14	Wood's Bay	12	230	6	47	10	210	10	68
15	Cape Montana	9	240,000	>800	37,000	29	25,000	2	8,300
16	Yellow Bay Biological Station	12	430	<2	56	11	90	<2	16
17	Blue Bay	12	220	<2	52	10	14,000	4	1,500
18	Finley Point State Park	18	230	<2	26	18	110	<2	19
19	Ducharme Fishing Access	14	720	8	230	10	26,000	30	3,000
20	Tee Point Swimming Area	13	150	6	60	10	2,000	2	240
21	Shoreline Motel	12	5,300	10	560	10	2,100	20	300
32	Big Arm View Trailer Park	15	510	<2	130	10	4,400	<2	530
33	Ross Cabins	10	1,200	<2	150	10	140	10	48

TABLE 2

SUMMARY OF FECAL COLIFORM COUNTS AT NEAR SHORE STATIONS

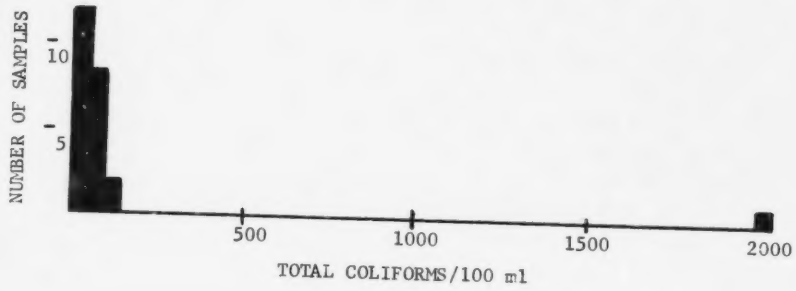
Station #	Location	July Survey # Samples	July Survey Fecal Coliforms/100 ml Maximum	July Survey Fecal Coliforms/100 ml Minimum	July Survey Fecal Coliforms/100 ml Average	August Survey # Samples	August Survey Fecal Coliforms/100 ml Maximum	August Survey Fecal Coliforms/100 ml Minimum	August Survey Fecal Coliforms/100 ml Average
1	Riverside Swimming Area	13	620	<2	58	10	70	<2	19
2	West End #93 Bridge, Polson	12	16	<2	4	10	2	<2	<2
3	Queen's Bay	16	4	<2	2	16	2	<2	<2
4	Indian Bay	18	54	<2	5	17	8	<2	3
5	Walstead Memorial Park	12	32	<2	6	10	24	<2	6
6	Flathead Lake State Park	15	30	<2	8	10	34	<2	6
7	Dayton Dock	13	78	<2	10	10	18	<2	6
9	Lakeside Public Beach	14	28	<2	6	9	6	<2	3
10	West Shore State Park	13	56	<2	6	10	52	<2	8
11	Bailey's Landing	12	60	<2	8	10	66	<2	12

TABLE 2 (CONT.)

SUMMARY OF FECAL COLIFORM COUNTS AT NEAR SHORE STATIONS

Station #	Location	July Survey # Samples	July Survey Fecal Coliforms/100 ml Maximum	July Survey Fecal Coliforms/100 ml Minimum	July Survey Fecal Coliforms/100 ml Average	August Survey # Samples	August Survey Fecal Coliforms/100 ml Maximum	August Survey Fecal Coliforms/100 ml Minimum	August Survey Fecal Coliforms/100 ml Average
14	Wood's Bay	12	12	<2	6	10	18	<2	4
15	Cape Montana	9	250	<2	58	29		<2	59
16	Yellow Bay Biological Station	12	10	<2	3	11	12	<2	3
17	Blue Bay	12	2	<2	<2	10	16	<2	5
18	Finley Point State Park	18	4	<2	2	18	6	<2	2
19	Ducharme Fishing Access	14	150	<2	28	10	1,500	10	190
20	Tee Point Swimming Area	13	44	<2	13	10	12	<2	5
21	Shoreline Motel	12	140	2	25	10	120	<2	22
32	Big Arm View Trailer Park	15	26	<2	4	10	20	<2	2
33	Ross Cabins	10	12	<2	4	10	14	<2	4

FREQUENCY DISTRIBUTION OF TOTAL AND FECAL COLIFORMS
AT STATION 20



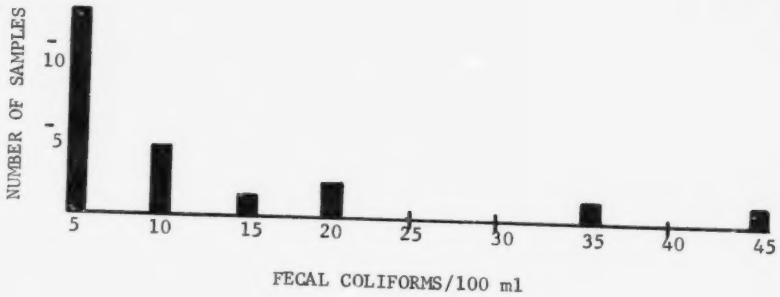


Figure 2

used to plot Figure 2 is 140, even though 18 of 22 values are less than 100. In contrast, the geometric mean for these same data is 41. The geometric mean is less affected by value extremes than is the arithmetic average. With skewed data, therefore, it may be preferable to employ the geometric mean rather than the arithmetic average to determine the point of central tendency. Tables 4 and 5, Appendix A, present a comparison of arithmetic averages with geometric means for all near shore stations. Geometric means of 5 of 20 stations exceeded the state standard during the July survey, and 11 of 20 stations during the August survey.

Vertical Distribution. Depth samples were taken intermittently at the near shore stations to provide some idea of the vertical distribution of coliforms throughout the water column (Tables 6 and 7 in Appendix A present a comparison of surface and depth samples). In most cases, the coliform counts are somewhat less at the 5 and 10 foot depths than at the surface. With a few exceptions, however, the difference between surface and depth samples is not of sufficient magnitude to be considered significant. Apparently, the water column is well mixed at the near shore stations. Vigorous wave action, which would promote vertical mixing, was commonly observed on the lake. Wind velocities of at least 10 to 20 miles per hour were recorded at the Kalispell Airport on 21 of the 24 sampling days. In some cases, gusts exceeded 50 mph (see Table 1, Appendix A).

Horizontal Distribution. The lateral distribution of coliforms along the shore was studied by a series of close interval sample collections. During the July survey, three special sampling runs were made along the Polson waterfront between the Shoreline Motel (Station 20) and Tee Point (Station 21). The area under study was known to have high concentrations of coliforms derived from a polluted drainage ditch. The results of these special sample runs are tabulated in Tables 8 and 9, Appendix A. It is apparent from these samples that the horizontal distribution of coliforms is nonuniform. Total coliform levels varied between values of several hundred thousand along a 100-yard stretch of shoreline.

The nonuniformity found in horizontal coliform distributions was even more dramatic in samples taken at Cape Montana west of the Yellow Bay Biological Station Commissary. Large changes in coliform concentrations within short distances were commonly found. This phenomenon is shown in Figures 3 and 4 which represent the coliform concentrations determined in samples collected along the Cape Montana shoreline and at distances of 50 and 100 feet offshore. It is evident from these figures that the lateral coliform distribution varies greatly along the shoreline and also between the shoreline and points offshore. Vertical mixing promoted by wave action apparently is effective in rapidly diluting the bacterial pollutants as they move into deeper water. These figures also

THE EFFECT OF WAVE ACTION ON THE HORIZONTAL

DISTRIBUTION OF TOTAL COLIFORMS FROM A POINT SOURCE

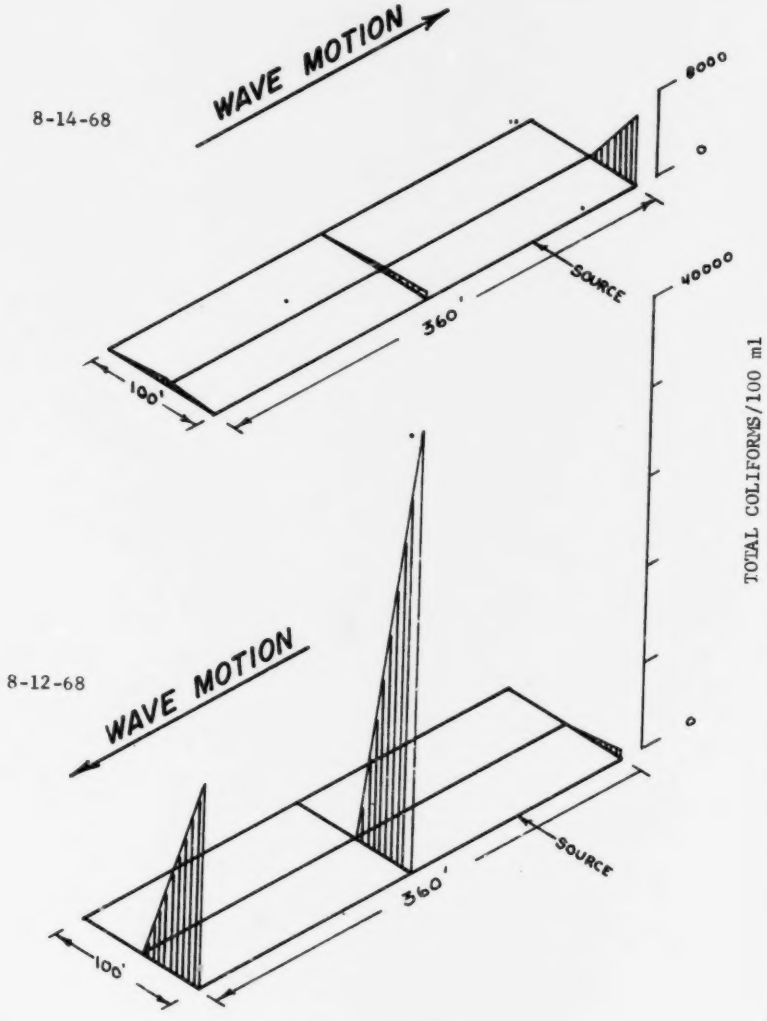


Figure 3

THE EFFECT OF WAVE ACTION OF THE HORIZONTAL

DISTRIBUTION OF FECAL COLIFORMS FROM A POINT SOURCE

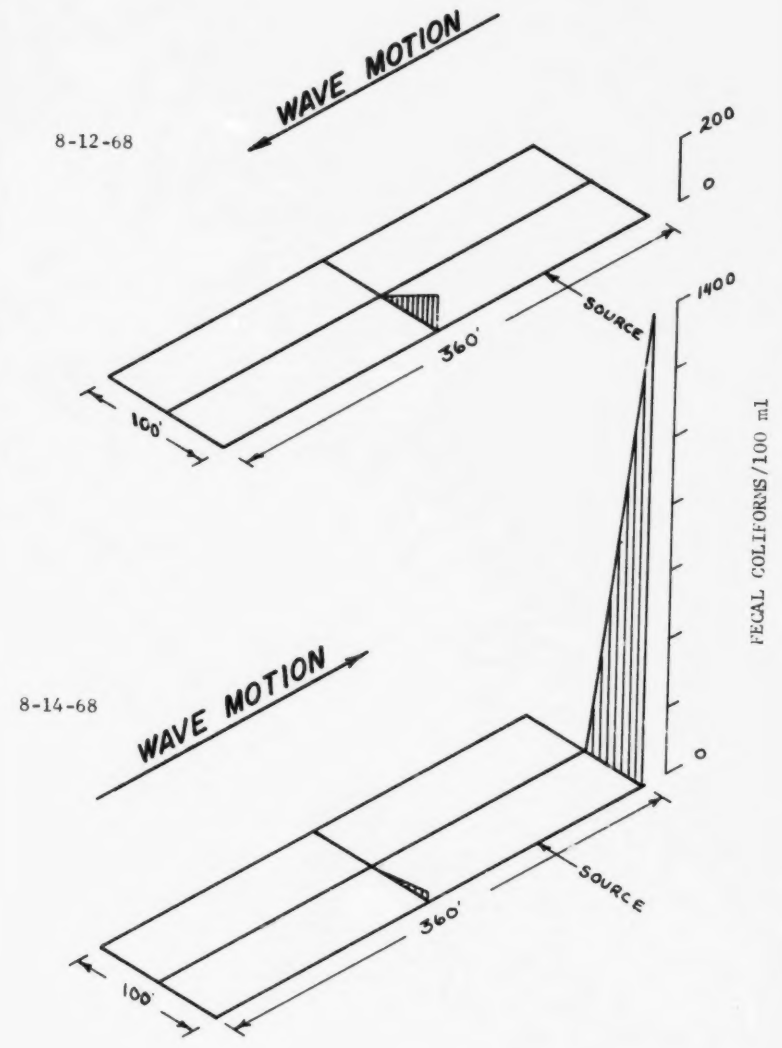


Figure 4

show the marked influence that wave movement has upon coliform concentrations. The bacteria are moved along the shoreline in the direction of the wave movement.

Off Shore Stations

A total of 67 off shore surface water samples were collected during the course of this study. The results of total and fecal coliform analyses on these samples are summarized in Tables 3 and 4. The coliform concentrations in off shore water were uniformly low. The maximum total coliform count measured among all off shore samples was 18, with most values being indeterminately low at <2. At no time were any fecal coliforms recovered from the off shore water.

Source Investigations

Rain Produced Land Runoff

Measurable rainfall was recorded during 11 of the 24 sampling days. The runoff resulting from this rainfall was probably responsible for the dramatic increases in coliform levels observed at some stations. Why the effect of runoff was highly significant at some stations and negligible at others is not well understood. It is noteworthy, however, that several stations which were most affected by the runoff are in close proximity to grazing lands. According to Geldreich et al.[7], the per capita coliform output

TABLE 3

SUMMARY OF COLIFORM COUNTS AT OFF SHORE STATIONS
JULY SURVEY

Station #	Samples #	Total Coliforms/100 ml			Fecal Coliforms/100 ml		
		Maximum	Minimum	Average	Maximum	Minimum	Average
22	4	<2	<2	<2	<2	<2	<2
23	4	<2	<2	<2	<2	<2	<2
24	4	8	<2	5	<2	<2	<2
25	4	<2	<2	<2	<2	<2	<2
26	4	<2	<2	<2	<2	<2	<2
27	4	<2	<2	<2	<2	<2	<2
28	4	<2	<2	2	<2	<2	<2
29	4	<2	<2	2	<2	<2	<2

TABLE 4

SUMMARY OF COLIFORM COUNTS AT OFF SHORE STATIONS
AUGUST SURVEY

Station #	Samples #	Total Coliforms/100 ml			Fecal Coliforms/100 ml		
		Maximum	Minimum	Average	Maximum	Minimum	Average
22	5	10	<2	4	<2	<2	<2
23	5	8	<2	3	<2	<2	<2
24	5	18	<2	6	<2	<2	<2
25	4	<2	<2	<2	<2	<2	<2
26	4	<2	<2	<2	<2	<2	<2
27	4	6	<2	3	<2	<2	<2
28	4	2	<2	<2	<2	<2	<2
29	4	<2	<2	<2	<2	<2	<2

for cows, hogs, sheep, and ducks ranges from 2.9 to 9.3 times that for man. Several hundred cattle were observed grazing in the fields adjacent to Station 19 and are presumed to have been primarily responsible for coliforms in that area. The relationship between land runoff and total coliform densities is presented in Figure 5. The pattern displayed in this Figure is typical of heavy rainfall which has been preceded by dry weather. The initial runoff carries very high coliform densities. Coliform counts then decrease rapidly during subsequent days of raintall due to the diluting action of the prolonged rain.

Rivers and Streams /

The following rivers and streams were sampled daily during the course of the surveys: (1) Flathead River, (2) Swan River, and (3) Stoner Creek. Average discharges taken from U. S. Geological Survey Records are: (1) Flathead River, 9,624 cubic feet per second (cfs); and (2) Swan River, 1,139 cfs. Average flow data for Stoner Creek are not available. An unnamed drainage ditch in Polson, locally referred to as the "government drain," was also sampled daily. Flow in this ditch during the surveys was estimated at 20 gallons per minute.

Results of analyses performed on contributory rivers and streams are summarized in Tables 5 and 6.

The Flathead and Swan Rivers contribute about 90 percent of the water entering Flathead Lake. The geometric means of

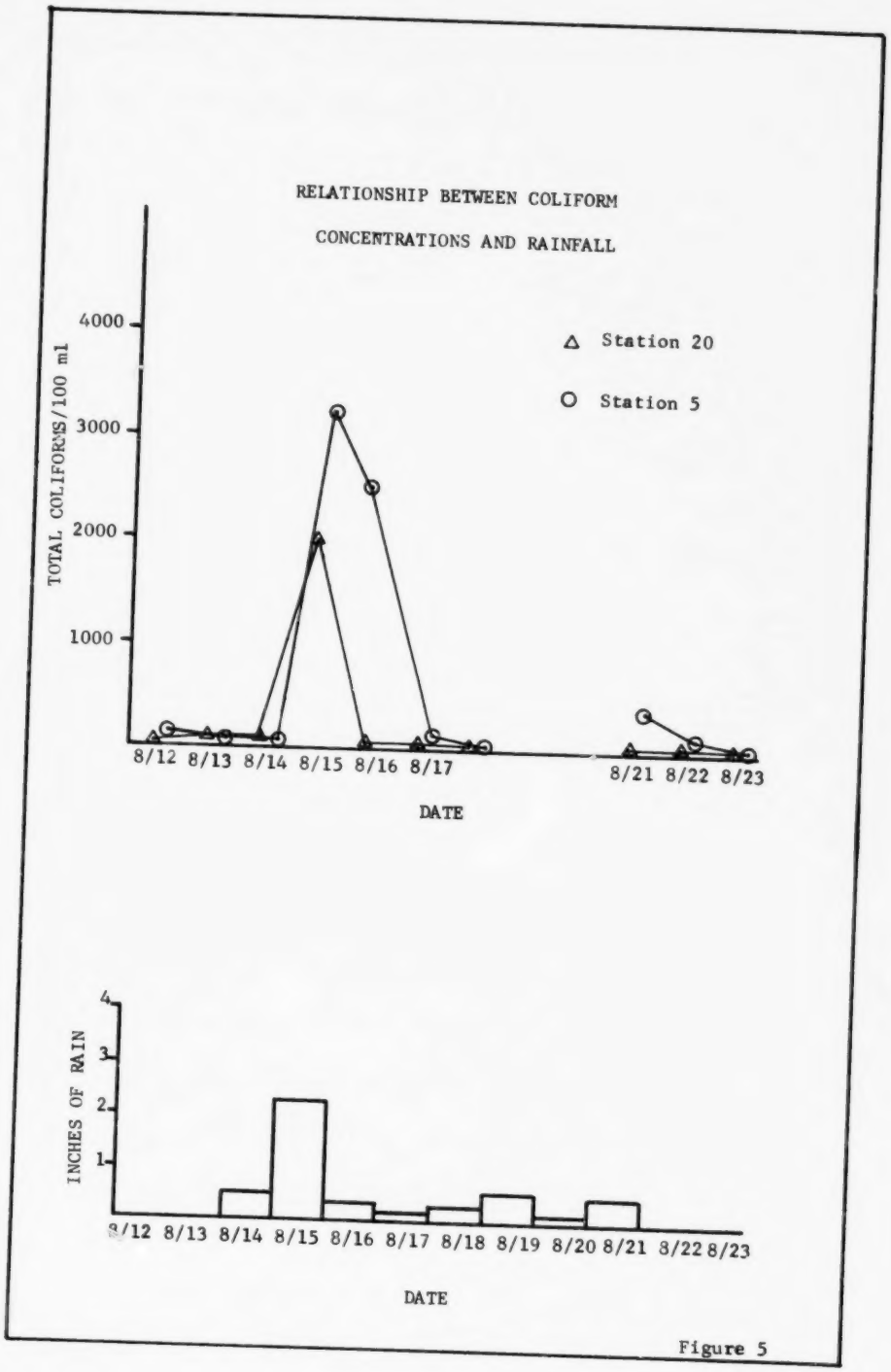

RELATIONSHIP BETWEEN COLIFORM
CONCENTRATIONS AND RAINFALL
TOTAL COLIFORMS/100 ml
4000
3000
2000
1000
Δ Station 20
O Station 5
8/12 8/13 8/14 8/15 8/16 8/17
8/21 8/22 8/23
DATE
INCHES OF RAIN
4
3
2
1
8/12 8/13 8/14 8/15 8/16 8/17 8/18 8/19 8/20 8/21 8/22 8/23
DATE

Figure 5

TABLE 5

SUMMARY OF TOTAL COLIFORM DENSITIES IN RIVERS AND STREAMS

Location	Total Coliforms/100 ml							
	July Survey				August Survey			
	Samples #	Maximum	Minimum	Geometric Mean	Samples #	Maximum	Minimum	Geometric Mean
Flathead River	12	240	2	27	10	620	10	46
Swan River	25	400*	8*	47*	15	1,300**	<2**	51**
Stoner Creek	14	430	8	85	30	1,700	40	270
Drainage Ditch A & W - Polson	6	520,000	120,000	260,000	10	640,000	11,000	170,000

*Combined Data of Stations 13 and 31
**Combined Data of Station 36 from 8/18 - 8/23

TABLE 6

SUMMARY OF FECAL COLIFORM DENSITIES IN RIVERS AND STREAMS

Location	Fecal Coliforms/100 ml							
	July Survey				August Survey			
	Samples #	Maximum	Minimum	Geometric Mean	Samples #	Maximum	Minimum	Geometric Mean
Flathead River	12	14	<2	3	10	34	<2	3
Swan River	25	18*	<2*	4*	15	28**	<2**	4**
Stoner Creek	14	100	8	24	30	200	2	25
Drainage Ditch A & W - Polson	6	450,000	18,000	60,000	10	69,000	1,900	10,000

*Combined Data of Stations 13 and 31
**Combined Data of Station 36 from 8/18 - 8/23

coliform bacteria contained in these rivers were quite low during this study, measuring less than 50/100 ml. The impact of these rivers on the coliform counts in the lake was minimal during this study. It is known[8/], however, that coliform concentrations increase in the Flathead River during the winter. The wintertime coliform concentration increase is probably due to a combination of increased survival of the coliforms due to lower temperature and less dilution.

Samples for the Swan River were taken at Big Fork Public Beach and Big Fork State Park during the first survey. Later, it was discovered that both sample points were upstream from the underwater outfall of the Big Fork Sewage Treatment Plant. This situation was taken into account during the second survey when five new sample stations were added, distributed above and below the Big Fork outfall. Table 7 presents a summary of the data taken from these new sample stations. It is notable that the geometric mean counts below the outfall are slightly lower than those upstream. The differences are actually so slight that they bear no real significance.

Coliform bacteria concentrations in Stoner Creek and the "government drain" in Polson are sufficiently high to have an effect on the receiving water. This is particularly true of the drainage ditch. Geometric mean concentrations of total and fecal coliforms found in the drainage ditch water, based upon 16 samples, were

as follows:

Total Coliforms - 200,000/100 ml

Fecal Coliforms - 20,000/100 ml

The source of the bacteria found in the drainage ditch water is probably septic tank seepage.

TABLE 7

SWAN RIVER - AUGUST SURVEY
EFFECT OF BIG FORK SEWAGE OUTFALL

Location	# Samples	Geometric Mean Total Coliforms/100 ml	Geometric Mean Fecal Coliforms/100 ml
Steel Bridge Below Power House	5	47	3
Highway #34 Bridge	5	81	7
100 Yards Downstream From Big Fork Outfall			
North 1/3 of River	5	47	4
Midstream	5	48	4
South 1/3 of River	5	58	4

Two stations added on Stoner Creek above and below Kalispell Air Force Station were intended to show what effect, if any, was produced by this installation discharging treated and chlorinated sewage into the creek. The geometric mean concentration of total and fecal coliforms found in 19 samples is as follows:

Stoner Creek	Geometric Mean Total Coliforms/100 ml	Fecal Coliforms/100 ml
1/4 Mile Above Air Force Station	230	24
1/4 Mile Below Air Force Station	270	29
At Mouth of Creek 1 Mile Below Air Force Station	320	18

No significant increase was recorded at the downstream station. These data indicate that the Air Force Station does not add significant numbers of coliform bacteria to Stoner Creek.

Septic Tank Seepage

Septic tank systems provide sewage treatment for the vast majority of summer homes which encircle Flathead Lake. Seepage from these septic tanks has long been considered a possible source of coliform bacteria observed in the lake. Evidence to substantiate this theory, however, has not been conclusive. The septic tank system serving the Yellow Bay Biological Station provided an excellent opportunity to determine whether septic tank seepage does, in fact, contribute significant numbers of coliform bacteria to the adjacent lake water. This septic tank system receives the combined waste of the Biological Station bath-house and commissary. During peak loadings, approximately

150 people are served by this system which is located on the west side of Cape Montana in front of the Biological Station Commissary.

Station 15 was established to monitor the effects of this drainfield. Results of sample analysis from Station 15 were presented previously in Tables 1 and 2. Maximum recorded coliform concentrations were as follows: (1) Total Coliforms - 240,000/100 ml and (2) Fecal Coliforms - 250/100 ml. The average total coliform concentration, based upon 38 samples taken during this study, was 15,000/100 ml.

Flourescein dye was flushed down the bath-house toilets on two different occasions by the Lake County Sanitarian in an attempt to link the septic tank system with the observed coliforms in the lake. No dye was observed to have reached the lake. A series of holes, A, B, and C, was then dug along the shoreline, 10 to 15 feet back from the water, at distances of 20, 30, and 40 yards north of Station 15 (see Figure 6). The holes were dug to a maximum depth of three feet. Ground water, with an odor similar to domestic sewage, entered hole B when a depth of 12-inches had been reached. Analysis of this water yielded a total coliform count of 100,000,000/100 ml and a fecal coliform count of 120,000/100 ml. In contrast, the ground water which entered hole A at a three-foot depth yielded a total coliform count of less than 100/100 ml and a fecal coliform count of 10/100 ml. No ground water was observed in hole C.

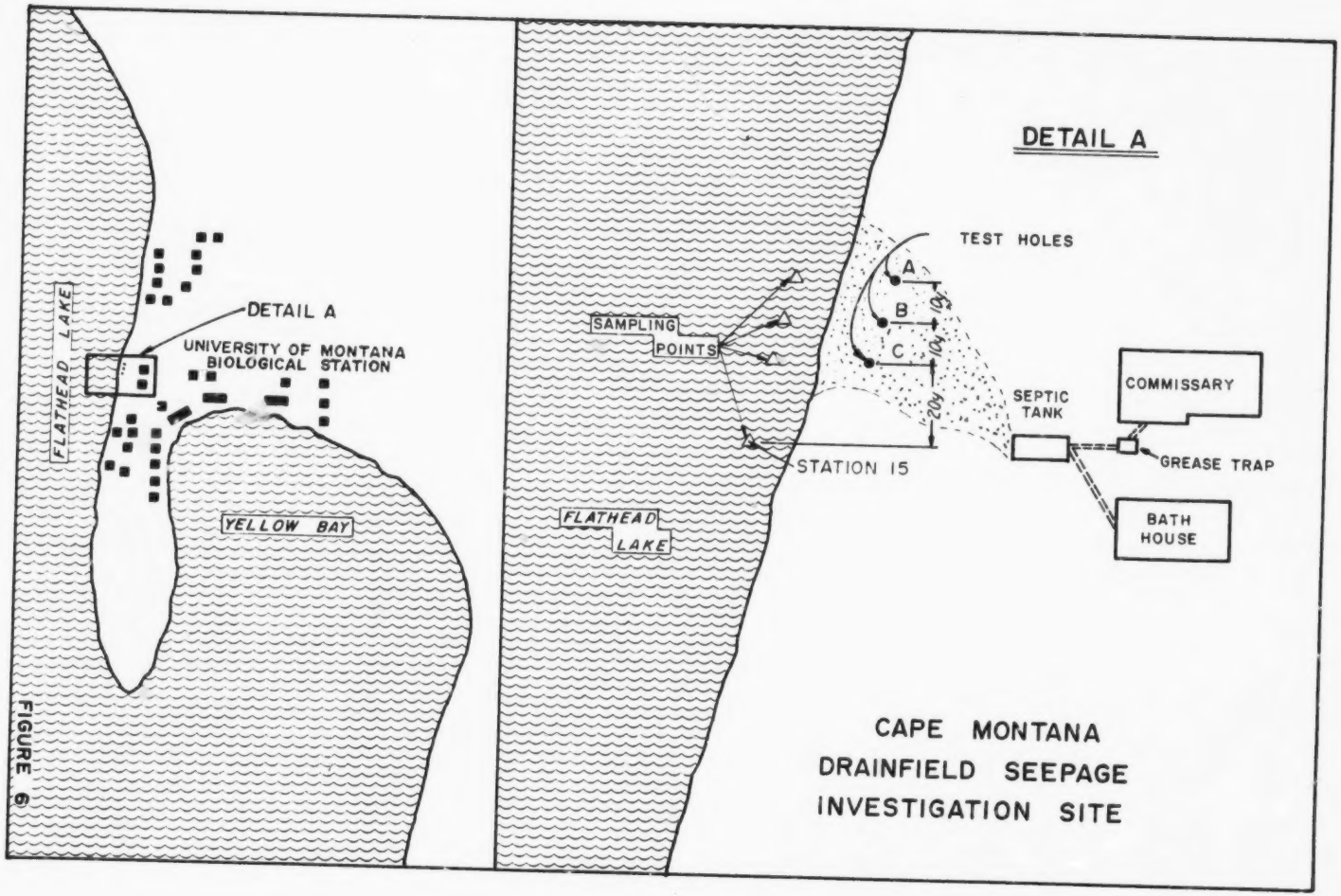

FLATHEAD LAKE
DETAIL A
UNIVERSITY OF MONTANA
BIOLOGICAL STATION
YELLOW BAY
DETAIL A
TEST HOLES
A
B
C
10'
10'
20'
SAMPLING
POINTS
STATION 15
FLATHEAD
LAKE
SEPTIC
TANK
COMMISSARY
GREASE TRAP
BATH
HOUSE
CAPE MONTANA
DRAINFIELD SEEPAGE
INVESTIGATION SITE

FIGURE 6

The only available source of the extremely high coliform levels found in hole B ground water was the Biological Station septic tank. According to Geldreich et al.[9], fecal coliforms from alpine soils, such as are found in the Flathead Lake area, are uniformly low. The highest fecal coliform concentration he and his co-workers reported for unpolluted alpine soils was 33/gram with the majority of samples indeterminately low (i.e., 1.8/gram). Theoretically, the fecal coliform density resulting from water percolating through this unpolluted alpine soil would be no greater than 3300/100 ml. In actuality, the fecal coliforms washed from the soil would be diluted by an excess of water, thus resulting in a measurable value which would be much lower than 3300/100 ml.

Lake water samples were taken at the shoreline opposite each test hole. Waves were moving north at this time. Results of analyses on these samples are as follows:

Sample Point	Total Coliforms/100 ml	Fecal Coliforms/100 ml
A	60	2
B	20,000	110
C	13,000	20

It is interesting to note the dramatic increase in coliform densities which occurs between point A and point B, all within a distance of approximately 10 yards. The coliforms measured in

the lake water at point C are apparently the result of wave action moving to the north from point B.

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7. Geldreich, E. E. et al., "Type Distribution of Coliform Bacteria in Feces of Warm Blooded Animals." JWPCF 34:295. March 1962.

8. University of Montana, Yellow Bay Biological Station. Unpublished data.

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APPENDIX A

DATA SUMMARIES

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TABLE 1

CLIMATOLOGICAL DATA - KALISPELL AIRPORT

Average* Temperature, Rainfall

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Temperature**	19.5	25.2	32.4	43.8	52.3	59.2	68.7	66.4	55.7	45.7	33.0	24.6
Precipitation***	0.5	0.4	0.7	0.9	1.7	2.2	1.0	0.9	1.1	0.7	0.6	0.6

Survey Weather Data

Date	Maximum Wind Speed (MPH) + Direction °	Temperature Range °F	Cloud Cover	Inches, Rainfall
7-15-68	14 @ 190°	48 - 72	Cloudy	Trace
7-16-68	10 @ 170°	39 - 76	Cloudy	Trace
7-17-68	17 @ 290°	55 - 76	Clear - Pt. Cloudy	0.3
7-18-68	13 @ 160°	40 - 79	Clear - Pt. Cloudy	
7-19-68	17 @ 250°	47 - 87	Clear - Pt. Cloudy	
7-20-68	17 @ 180°	51 - 65	Cloudy	0.50
7-21-68	11 @ 40°	43 - 76	Clear	
7-22-68	15 @ 350°	42 - 76	Clear	
7-23-68	20 @ 30°	49 - 75	Pt. Cloudy	
7-24-68	15 @ 350°	45 - 78	Pt. Cloudy	
7-25-68	12 @ 20°	50 - 79	Pt. Cloudy	
7-26-68	17 @ 20°	48 - 88	Clear	
8-12-68	17 @ 350°	42 - 83	Clear	
8-13-68	16 @ 10°	50 - 80	Cloudy	
8-14-68	10 @ 20°	58 - 67	Cloudy	0.50
8-15-68	9 @ 170°	52 - 53	Cloudy	2.22
8-16-68	8 @ 180°	46 - 70	Cloudy	0.29
8-17-68	14 @ 150°	49 - 57	Mostly Cloudy	0.20
8-18-68	13 @ 360°	54 - 66	Cloudy	0.25
8-19-68	12 @ 160°	42 - 68	Cloudy	0.55
8-20-68	9 @ 240°	47 - 66	Pt. Cloudy	0.12
8-21-68	15 @ 160°	50 - 65	Pt. Cloudy	0.44
8-22-68	12 @ 140°	42 - 67	Mostly Cloudy	0.09
8-23-68	14 @ 150°	-	Pt. Cloudy	

*Based upon U. S. Weather Bureau Records 1925-1954
**Average Monthly Temperature in Degrees Farenheit
***Precipitation in Inches

TABLE 2

DAILY TOTAL COLIFORM COUNTS - NEAR SHORE STATIONS
TOTAL COLIFORMS/100 ml

Station #	8-12	8-13	8-14	8-15	8-16	8-17	8-18	8-21	8-22	8-23
1	830	240	160	110	340	240	3,300	1,300	78	1,700
2	16	42	36	62	46	12	4	20	8	28
3	14	4	110	--	24	570	50	120	90	18
4	20	6	10	--	2	52	54	100	2	<2
5	150	88	46	3,200	2,500	110	60	410	160	22
6	150	160	32	4,900	270	130	140	130	48	38
7	100	200	54	140	90	20	600	60	120	4
9	--	26	290	190	18	30	20	100	22	18
10	20	26	32	550	36	20	88	72	5,300	10
11	54	18	610	220	120	240	170	290	30	54
14	40	24	74	180	20	210	10	28	64	30
15	25,000	<100	7,500	400	1,800	800	48	2	240	40
16	2	14	18	2	90	20	<2	6	2	8

← RAIN →

TABLE 2 (CONT.)

DAILY TOTAL COLIFORM COUNTS - NEAR SHORE STATIONS
COLIFORMS/100 ml

Station #	8-12	8-13	8-14	8-15	8-16	8-17	8-18	8-21	8-22	8-23
17	4	94	12	14,000	240	82	72	70	18	22
18	<2	2	16	--	10	56	14	110	<2	4
19	30	270	90	26,000	1,000	2,300	90	50	70	400
20	34	66	58	2,000	90	48	12	12	36	2
21	46	340	40	84	62	2,100	28	250	38	20
32	20	<2	110	4,400	260	160	110	110	4	160
33	16	46	32	34	36	140	98	36	30	10
			←	RAIN			→			

TABLE 3

DAILY FECAL COLIFORM COUNTS - NEAR SHORE STATIONS
FECAL COLIFORMS/100 ml

Station #	8-12	8-13	8-14	8-15	8-16	8-17	8-18	8-21	8-22	8-23
1	8	4	<2	4	2	10	70	62	14	14
2	2	<2	<2	2	2	2	<2	<2	<2	<2
3	<2	<2	<2	-	<2	<2	<2	<2	<2	<2
4	2	<2	2	-	<2	<2	<2	4	<2	<2
5	2	2	2	24	2	6	<2	14	<2	<2
6	<2	<2	2	34	6	4	8	2	<2	<2
7	4	6	10	14	2	2	18	<2	<2	<2
9	-	6	6	4	4	<2	2	<2	<2	<2
10	<2	<2	<2	6	<2	4	52	<2	6	<2
11	6	<2	66	14	<2	4	14	10	<2	2
14	<2	<2	<2	2	<2	18	<2	6	2	<2
15	8	<2	<2	<2	2	56	2	<2	<2	<2
16	<2	<2	<2	<2	<2	12	<2	<2	<2	<2

← RAIN →

TABLE 3 (CONT.)

DAILY FECAL COLIFORM COUNTS - NEAR SHORE STATIONS
FECAL COLIFORMS/100 ml

Station #	8-12	8-13	8-14	8-15	8-16	8-17	8-18	8-21	8-22	8-23
17	<2	<2	<2	16	<2	14	2	<2	<2	<2
18	2	<2	<2	-	<2	<2	6	<2	<2	<2
19	14	86	2	1,500	140	140	24	10	14	10
20	6	2	2	12	8	8	4	4	<2	<2
21	<2	64	<2	2	<2	>120	8	14	2	<2
32	4	<2	<2	2	2	2	<2	<2	<2	<2
33	<2	2	8	<2	2	14	4	<2	<2	<2
			←		RAIN		→			

TABLE 4

COMPARISON OF ARITHMETIC AVERAGES AND GEOMETRIC MEA .
NEAR SHORE STATIONS

	July Survey			August Survey		
		Total Coliforms/ 100 ml			Total Coliforms/ 100 ml	
# Station	# Samples	Average	Geometric Mean	# Samples	Average	Geometric Mean
1	13	220	86	10	830	420
2	12	47	10	10	27	21
3	16	19	6	16	88	38
4	18	11	5	17	45	15
5	12	59	41	10	680	190
6	15	130	44	10	600	150
7	13	97	55	10	140	74
9	14	86	33	9	79	44
10	13	39	20	10	620	68
11	12	53	26	10	180	110
14	12	47	24	10	68	44
15	9	37,000	2,500	29	8,300	290
16	12	56	10	11	16	8
17	12	52	17	10	1,500	69
18	18	26	9	18	19	8
19	14	230	88	10	3,000	300
20	13	60	42	10	240	40
21	12	560	76	10	300	90
32	15	130	23	10	530	76
33	10	150	24	10	48	37

TABLE 5

COMPARISON OF ARITHMETIC AVERAGES AND GEOMETRIC MEANS
NEAR SHORE STATIONS

	July Survey			August Survey		
		Fecal Coliforms/ 100 ml			Fecal Coliforms/ 100 ml	
# Station	# Samples	Average	Geometric Mean	# Samples	Average	Geometric Mean
1	13	58	11	10	19	9
2	12	4	3	10	2	2
3	16	2	2	16	2	2
4	18	5	3	17	3	2
5	12	6	3	10	6	4
6	15	8	4	10	6	4
7	13	10	5	10	6	4
9	14	6	4	9	3	3
10	13	6	3	10	8	4
11	12	8	3	10	12	6
14	12	6	4	10	4	3
15	9	58	17	29	59	4
16	12	3	2	11	3	2
17	12	2	2	10	5	3
18	18	2	2	18	2	2
19	14	28	10	10	190	35
20	13	13	7	10	5	4
21	12	25	5	10	22	6
32	15	4	3	10	2	2
33	10	4	3	10	4	3

TABLE 6

COMPARISON OF TOTAL COLIFORMS FOUND IN SURFACE VS DEPTH SAMPLES
TOTAL COLIFORMS/100 ml

Station #	Depth Ft.	7-17	7-19	7-22	7-24	7-25	8-12	8-14	8-17	8-23
3	0.5	4	10	--	<2	100	20	--	--	18
3	5.0	2	2	--	<2	2	14	--	--	70
4	0.5	20	4	4	<2	20	150	26	46	
4	5.0	22*	<2	<2	<2	2	20	10	90	
15	0.5	20	2	--	1,100	>800	<2	2,200	--	--
15	10.5	4	<2	--	38	88	>8,000	70	--	--
18	0.5	44	16	2	10	20	<2	--	10	4
18	5.0	6	<2	<2	10	44	2	--	22	10

*Average of two values

TABLE 7

COMPARISON OF FECAL COLIFORMS FOUND IN SURFACE VS DEPTH SAMPLES
FECAL COLIFORMS/100 ml

Station #	Depth Ft.	7-17	7-19	7-22	7-24	7-25	8-12	8-14	8-17	8-23
3	0.5	<2	2	--	<2	2	<2	--	--	<2
3	5.0	<2	<2	--	<2	<2	<2	--	--	<2
4	0.5	2	<2	<2	<2	6	8	2	<2	<2
4	5.0	<2	<2	<2	<2	<2	2	<2	2	<2
15	0.5	<2	<2	4	<2	6	<2	<2	--	--
15	10.0	<2	<2	<2	<2	<2	<2	<2	--	--
18	0.5	2	<2	<2	4	<2	2	2	<2	<2
18	5.0	<2	2	<2	2	<2	<2	<2	<2	<2

TABLE 8

TOTAL COLIFORM RESULTS - POLSON SPECIAL SAMPLE RUN
TOTAL COLIFORMS/100 ml

Date	Shoreline* Motel	100 Yards* West of A & W	A & W*	100 Feet Out From A & W	100 Yards Out From A & W	100 Yards* East of A & W	100 Yards* West of Tee Point	Tee Point*
7-24-68	120	200	590	---	<10	2	<2	4
7-25-68	300	490	2,400	150	--	14	<2	6
7-26-68	130	170	4,200	1,200	--	340	16	380

*Taken 10 Feet From Shore

TABLE 9

FECAL COLIFORM RESULTS - POLSON SPECIAL SAMPLE RUN
FECAL COLIFORMS/100 ml

Date	Shoreline* Motel	100 Yards* West of A & W	A & W*	100 Feet Out From A & W	100 Yards Out From A & W	100 Yards* East of A & W	100 Yards* West of Tee Point	Tee Point*
7-24-68	10	10	140		2	<2	2	<2
7-25-68	32	24	190	10	-	2	<2	<2
7-26-68	16	14	250	210		16	<2	4

*Taken 10 Feet From Shore

TABLE 10

DAILY TOTAL COLIFORM COUNTS
SWAN RIVER

Location	Total Coliforms/100 ml*				
	8-18	8-20	8-21	8-22	8-23
Steel Bridge Below Power House	64	70	16	60	56
Highway #34 Bridge	1,300	36	30	50	50
North 1/3 of River, 100 Yards West of Outfall	62	2,100	10	90	<2
Midstream, 100 Yards West of Outfall	64	150	42	20	32
South 1/3 of River, 100 Yards West of Outfall	140	90	44	30	38
	← RAIN →				

*All Samples Taken at Surface

TABLE 11

DAILY FECAL COLIFORM COUNTS
SWAN RIVER

Location	Fecal Coliforms/100 ml*				
	8-18	8-20	8-21	8-22	8-23
Steel Bridge Below Power House	14	4	2	<2	<2
Highway #34 Bridge	16	12	6	6	2
North 1/3 of River, 100 Yards West of Outfall	10	18	<2	<2	<2
Midstream, 100 Yards West of Outfall	20	8	<2	<2	<2
South 1/3 of River, 100 Yards West of Outfall	28	2	4	<2	<2
	← RAIN →				

*All Samples Taken at Surface

TABLE 12

MUNICIPAL SEWAGE TREATMENT FACILITIES

Municipality	Population	Population Served	Treatment	Est. Flow MGD	Remarks
Kalispell	10,151	11,000	Primary & Chlorination	2.0	Storm Water Combined
Kalispell Air Force Station, Lakeside	200	200	Imhoff Tank & Lagoons	0.02	
Big Fork	500	100	Secondary & Chlorination	0.02	
Polson	2,315	2,300	Lagoons	0.3	Storm Water Combined

APPENDIX B

SAMPLE STATION DESCRIPTIONS

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TABLE 1

SAMPLE POINT LOCATIONS OF
NEAR SHORE STATIONS

Station #	Location	Sampling Point	Approximate Depth At Point
1	Riverside Swimming Area	Foot of Boat Dock	6-12 in.
2	West End - Highway #93 Bridge - Polson	North Side of Bridge	2 ft.
3	Queen's Bay	20 Yards from West Shore	8 ft.
4	Indian Bay	20 Yards from South-east Shore	8 ft.
5	Walstead Park	From Shoreline	3-6 in.
6	Flathead Lake State Park	Foot of Boat Dock	6-12 in.
7	Dayton	Large Dock - South Side of Town	6-12 in.
9	Lakeside Public Beach	Foot of Dock	6-12 in.
10	West Shore State Park	Foot of Dock	6-12 in.
11	Bailey's Landing, Somers	Boat Launching Ramp	3-6 in.
14	Wood's Bay	Thunderbird Gas Station Dock	6-12 in.
15	Cape Montana	20 Yards Offshore - Ladyville Beach	7 ft.
15A	Cape Montana	Shoreline - Front of Commissary	3-6 in.

TABLE 1 (CONT.)

SAMPLE POINT LOCATIONS OF
NEAR SHORE STATIONS

Station #	Location	Sampling Point	Approximate Depth At Point
16	Yellow Bay Biological Station	Boat Dock	6 ft.
17	Blue Bay Restaurant	Foot of Restaurant Dock	3 ft.
18	Finley Point State Park	20 Yards Offshore	6 ft.
19	Ducharme Fishing Access	Boat Launching Ramp	2-4 in.
20	Polson Golf Course	Foot of Swimming Dock	6 in.-2 ft.
21	Shoreline Motel	North Side of Land Fill	6 in.
30	Somers Water Pumphouse	200 ft. East of Pumphouse	6 in.
32	Big Arm View Trailer Park	Foot of Dock	6-12 in.
33	Ross Cabins	Foot of Dock	6-12 in.

TABLE 2

SAMPLE POINT LOCATIONS OF
OFF SHORE STATIONS

Station #	Intersects	Approximate Depth in Feet
22	N 48°00' W 114°07'30"	60
23	N 47°55' W 114°07'30"	150
24	N 47°55' W 114°02'30"	60
25	N 47°50' W 114°17'30"	50
26	N 47°50' W 114°17'30"	200
27	N 47°50' W 114°02'30"	30
28	N 47°45' W 114°07'30"	20
29	N 47°45' W 114°02'30"	60

TABLE 3

SAMPLE POINT LOCATIONS OF
RIVERS AND STREAMS

Station #	Location	Sampling Point	Approximate Depth At Point
8	Stoner Creek	West Entrance of Culvert at Mouth	2 ft.
8A	Stoner Creek	1/4 Mile Upstream, A. F. Station	2-4 in.
8B	Stoner Creek	1/4 Mile Downstream, A. F. Station	2-4 in.
12	Flathead River	East Side - Fisherman's Bridge - Highway #208	3-6 in.
13	Swan River (Big Fork State Park)	At Shoreline	3-6 in.
31	Swan River (Big Fork Public Beach)	Base of Dock	2 ft.
34	"Government Drain" 100 Yards West of Jim's Marina	50. Yards Upstream From Mouth	2-4 in.
35	Swan River (Beneath Highway #35 Bridge)	Midstream	--
36A	Swan River, 100 Yards Downstream Big Fork Outfall	North 1/3	--
36B	Swan River, 100 Yards Downstream, Big Fork Outfall	Midstream	--
36C	Swan River, 100 Yards Downstream, Big Fork Outfall	South 1/3	--
37	Swan River, Beneath Bridge at Base of Power Plant	Midstream	--